ADHESIVE SEALED ORGANIC OPTOELECTRONIC STRUCTURES

FIELD OF THE INVENTION

The present invention relates to structures that protect organic optoelectronic devices from the surrounding environment.

BACKGROUND OF THE INVENTION

Organic optoelectronic devices, including circuits, such as organic light emitting diodes, organic electrochromic displays, organic photovoltaic devices and organic thin film transistors, are known in the art and are becoming increasingly important from an economic standpoint.

As a specific example, organic light emitting devices ("OLEDs"), including both polymer and small-molecule OLEDs, are potential candidates for a great variety of virtual- and direct-view type displays, such as lap-top computers, televisions, digital watches, telephones, pagers, cellular telephones, calculators and the like. Unlike inorganic semiconductor light emitting devices, organic light emitting devices are generally simple and relatively easy and inexpensive to fabricate. Also, OLEDs readily lend themselves to applications requiring a wide variety of colors and to applications that concern large-area devices. In general, two-dimensional OLED arrays for imaging applications are known in the art and are typically composed of a plurality of OLEDs (one or more of which forms a pixel) arranged in rows and columns. Each individual OLED in the array is typically constructed with a first transparent anode (such as ITO), an organic electroluminescent layer on the first electrode, and a metallic cathode on the organic electroluminescent medium. Other OLED architectures are also known in the art such as transparent OLEDs (transparent cathode contact), and inverted OLEDs.

In forming an OLED, a layer of reactive metal is typically utilized as the cathode to ensure efficient electron injection and low operating voltages. However, reactive metals and their interface with the organic material are susceptible to oxygen and moisture, especially during operation, which can severely limit the lifetime of the devices. Moreover, moisture and oxygen are also known to increase "dark spot areas" in connection with OLEDs. Components of various other organic optoelectronic devices (e.g., organic electrochromic displays, organic photovoltaic devices and organic thin film transistors) are likewise susceptible to attack from exterior environmental species, including water and oxygen.

SUMMARY OF THE INVENTION

The above and other challenges are addressed by the present invention. According to an embodiment of the invention, an organic optoelectronic device structure is provided. The organic optoelectronic device structure comprises: (a) a polymer substrate layer; (b) a first barrier region disposed over a first face of the polymer substrate layer; (c) an organic optoelectronic device, selected from as organic light emitting diode, an organic electrochromic display, an organic photovoltaic device and an organic thin film transistor, disposed over a second face of the polymer substrate layer opposite the first face; (d) a second barrier region disposed over the second face of the polymer substrate layer and over the organic optoelectronic device; and (e) an adhesive region. The adhesive region is disposed between the polymer substrate layer and the second barrier region such that it bonds the polymer substrate layer to the second barrier region. Moreover, the adhesive region encircles the organic optoelectronic device such that the organic optoelectronic device is completely surrounded by the adhesive region, the polymer substrate layer and second barrier region.

The polymer substrate layer preferably ranges from 75 to 625 microns in thickness and is preferably a fluorocarbon polymer, a polyethersulphone, a polyimide, a polyester, such as polyethylene terephthalate, or a material such as polymethylmethacrylate (PMMA).

The first barrier region preferably comprises at least one planarizing layer and at least one high-density layer, more preferably an alternating series of at least two planarizing layers and at least two high-density layers, and most preferably an alternating series of 3 to 7 planarizing layers and 3 to 7 high-density layers. Fluorinated polymers, parylenes, and polyacrylates are preferred materials for the planarizing layers, while metal oxides, metal nitrides, metal carbides, metal oxynitrides, or combinations, may be used for the high-density layers. Silicon oxide, silicon nitride, aluminum oxide, indium tin oxide and zinc indium tin oxide are preferred materials for the high-density layers.

In some instances, the second barrier region comprises a metal layer, such as a metal foil. In others, the second barrier layer comprises (a) a polymer layer adjacent the adhesive region and (b) an alternating series of at least two planarizing layers and at least two high-density layers over the polymer layer.

A gettering material is preferably provided in connection with the organic optoelectronic device structure and is situated such that it, along with the organic optoelectronic device, is surrounded by the adhesive region, the polymer substrate layer and second barrier region.

The adhesive region preferably comprises an ultraviolet-curable adhesive material or a thermally curable adhesive material, more preferably an ultraviolet- or thermally-curable epoxy material.

In some embodiments, the organic optoelectronic device structure is further provided with a third barrier region that covers at least the edges of the polymer substrate layer. In other embodiments, the third barrier region covers at least the edges of the organic optoelectronic device structure, and in still other embodiments, the third barrier region encapsulates the entire organic optoelectronic device structure. The third barrier region preferably comprises an epoxy material, which can be provided, for example, via a dipping process. The third barrier region is also preferably provided with a gettering agent, such as calcium oxide.

Preferred organic optoelectronic devices for the practice of the present invention include organic light emitting devices, organic electrochromic displays, organic photovoltaic devices and organic thin film transistors. Most preferably the organic optoelectronic devices are organic light emitting devices, which comprise an anode, a cathode and an organic emissive layer.

One advantage of the present invention is that an organic optoelectronic structure is produced that provides an effective barrier between the organic optoelectronic device and the ambient atmosphere, reducing adverse effects due to chemical species in the ambient atmosphere, such as moisture and oxygen.

Another advantage of the present invention is that an organic optoelectronic structure is provided that maintains good adhesion between its various layers.

These and other embodiments and advantages of the present invention will become readily apparent to those of ordinary skill in the art upon review of the disclosure to follow.